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Building Performance Analysis Using Interactive Multimedia Concepts

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SYNOPSIS

We describe LBL's involvement with multimedia concepts by discussing several modules of an advanced computer-based building envelope design tool. The qualitative and quantitative aspects of the building design process are accommodated within the same design tool which uses object-oriented programming procedures. This computer-based concept utilizes images (buildings, landscapes, models, documents, etc.), expert systems (knowledge bases, i.e., lighting design, site planning, HVAC design, etc.), and data bases (design criteria, utility rates, climatic data, etc.) in addition to more traditional simulation models to evaluate building design alternatives.

INTRODUCTION

The Windows and Daylighting Group at Lawrence Berkeley Laboratory is involved in research related to analyzing and improving the energy and comfort performance of window systems. This has involved developing new glazing materials, as well as defining new methods of analysis of fenestration systems, so that critical design decisions can be made more efficiently, accurately, and in a timely manner. In addition to these research-oriented activities, we have also been exploring new methods of transferring technology to the building industry, particularly developers, architects, engineers, and building owners. This paper describes the development of prototype interactive multimedia building design and performance analysis tools and information data bases that provide energy efficient building design guidelines.

Recently, major advances in microcomputers, optical disc, video, and audio technology, in parallel with the development of innovative authoring software has resulted in a unique opportunity to enhance the way individuals design buildings and evaluate building energy performance. It is now possible to use non-linear interactive techniques that complement each other and expand the design experience. This multidimensional environment is called "interactive multimedia."

Interactive multimedia became a reality with the development in the mid-1980s of personal computers and the associated hardware and software that facilitated simplified object-oriented programming, creation of sophisticated computer graphics, digitization of sound, and interfacing with external imaging devices.

We have long been interested in developing design tools that allow users to consider non-quantitative issues as well as numeric performance data (Selkowitz, Papamichael, and Wilde 1986). Multimedia should be applied to the development of new design tools for several reasons. The use of video provides an avenue for qualitative analysis by the user. This is especially useful when it can be viewed simultaneously with numeric, text or diagrammatic information, for it allows the designer to synthesize a total conceptual image of the issue at hand. Video also permits the element of time to be explored. Time lapse photography or full motion sequences can show aspects of design that cannot be expressed in static media or with single images. Additionally, dynamic concepts can be explored through the use of computer-based animation which can often be complemented by still video images of a real space.

The paper discusses several components of a planned building envelope design tool that uses multimedia techniques to reinforce and highlight various aspects of the building design process: (1) a Daylight Design Tool providing guidance on the implementation and use of daylighting in commercial buildings; (2) an Expert System that is in the early stages of development and will eventually provide lighting and envelope design solutions; (3) a Fenestration Performance Design Tool that evaluates the energy and comfort performance of windows as a function of specific design and context variables; and (4) an Energy Information Kiosk that was designed to function as an online database for an electric utility in California.

DAYLIGHTING DESIGN TOOL

To better understand the capabilities and limitations of these multimedia tools, we have prototyped a comprehensive daylighting design tool using multimedia concepts, Figure 1 (Schuman and Selkowitz 1989).



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Figure 1. The viewer makes her own path through a hypermedia case study. Here, she takes an interactive video tour through the building. By clicking the mouse at various points around the axonometric drawing at the right, she receives a corresponding view on the left.

Individual modules have been developed to function as stand-alone units and as integrated components of a larger tool. These modules fall into the following categories:

- Case studies
- Databases
- Educational/conceptual aids
- Schematic analysis

Case studies are important for illustrating concepts and lessons learned from past experience. Their use varies from being the source of inspiration and creation of a new idea to helping solve potential problems that designers face during the design process. Our prototype tool documents buildings notable for daylighting. We have found multimedia an especially rich environment in which to explore the potential of case studies to influence future design decisions. Our focus has been on convenient case study access, including variable searching, sorting, and retrieval techniques; multiple display capabilities to facilitate direct comparison of items such as light levels, energy consumption, etc.; user determined quantity of data; and options dealing with specific design strategies.

Databases include a bibliography of daylighting references and a catalog of all images on a videodisc. We have implemented sophisticated search, sort, and query mechanisms in these databases which allow us to perform a variety of functions with the data, including dynamic linking with the rest of the modules. For example, the reference for a piece of text in an educational module can be instantly located, or an image on the video monitor quickly identified. We hope to eventually include product catalogs among our databases, complete with video images, and linked to other processes such as expert systems.

Educational modules are intended to be explanatory or conceptual aids. The use of video, sound, and animation take education beyond static, unidimensional media such as books. The intent is not to replace traditional information sources, but rather to supplement them. We take advantage of several multimedia techniques in our educational modules about daylighting principles, the construction of physical models, and thermodynamics associated with windows. Of particular interest is the use of interactive video to further engage the viewer in the learning process. One module we call Virtual Space is an interactive tool to study light distribution as parameters change, such as window size, outside conditions, and surface reflectances. The viewer uses the computer screen to point and click for the design changes, and the resulting pre-stored image is shown on a video monitor as controlled by the viewer. The purpose of conceptual modules is to function both as stand-alone learning units and to support other processes within the larger tool.

Schematic analysis uses simplified calculation tools at any stage of design, particularly the earliest stages. We use methods such as rule-of-thumb calculation procedures or simplified regression equations to predict the performance of a schematic design. For example, we have developed intuitive and graphic tools to gauge performance of several design scenarios, including lighting analysis in atria and fenestration performance in offices. The fenestration analysis tool allows determination of heating, cooling, lighting, and comfort indices as a function of all important fenestration properties. The performance data are predicted from algebraic equations that are based on an extensive set of DOE-2 simulations (Simulation Research Group 1989).

EXPERT SYSTEMS

There has been a major effort over the last decade to encode building design expertise through the application of Expert or Knowledge-Based Systems (ES or KBS) techniques, which emerged from the field of Artificial Intelligence (AI). Prototype expert systems are currently available to diagnose problems with various types of building equipment and select building components and systems. Initial attempts at encoding building design expertise to create expert systems for the design of buildings has met with little success. This is, in part, due to the fact that "design" is a very complex process requiring a series of decisions based not only on quantifiable criteria, but also on qualitative criteria and value judgments.

Through an in-depth analysis of the design process and design methodology, we have identified the fundamental design activities that can be delegated to a computer and those that cannot and must therefore be provided by the designer. The theory behind this new approach is detailed in

Papamichael (1991) and Papamichael and Selkowitz (1990). We model the design process around three basic iterative design activities:

- Formulation of design criteria
- Generation of potential design solutions
- Evaluation

To test and validate our conclusions and demonstrate our approach, we are developing a prototype computer program for the design of electric lighting and fenestration systems in office buildings. Issues addressed include comfort, energy and cost. Through the development of this prototype we explore methods to allow the system to grow through use, learning the specific values of its users. Our focus is on the development of a protocol that will allow gradual expansion with respect to additional design criteria, as well as other building components and systems. Since the software prototype will have to address a wide variety of quantitative and qualitative criteria, the use of a multimedia interface is a useful feature of this tool.

PERFORMANCE DESIGN TOOL

We have shown in several studies (Sullivan and Selkowitz 1989) the feasibility of condensing DOE-2 building energy simulation results into relatively simple, compact expressions, i.e., indices that express performance relative to glazing properties. We used such methods to create a prototype fenestration performance design tool that uses a graphically-oriented, user-friendly interface.

The uniqueness of the program design stems from the use of icons to drive selections made by the user enabling immediate branching and exploring of alternate parts of the program. We employ a library of images and tabular data representative of different building types and window and shading systems to assist the user in making decisions and evaluating alternative configurations. We also use animation in reporting calculated results and, although not yet implemented, to explain concepts such as daylighting and its effect on performance.

Figure 2 shows an output screen from the tool. It presents calculated performance indices for several zones of a typical commercial building module. The bar charts are provided to give an indication of the relative performance of four input fenestration systems. A composite results chart such as this enables users to make rapid decisions and either proceed or redefine the configuration variables which can be accessed by the icons presented along the left hand side of the screen.

The first icon provides for a selection of geographic location. The second icon refers to selection of building type and the third and fourth icons are used to describe the perimeter zones and fenestration system of the building. The last icon refers to the use of a "weighting function" to calculate an overall fenestration system "figure of merit." This program represents one of the first uses of multimedia based software for analysis of building energy and comfort performance.

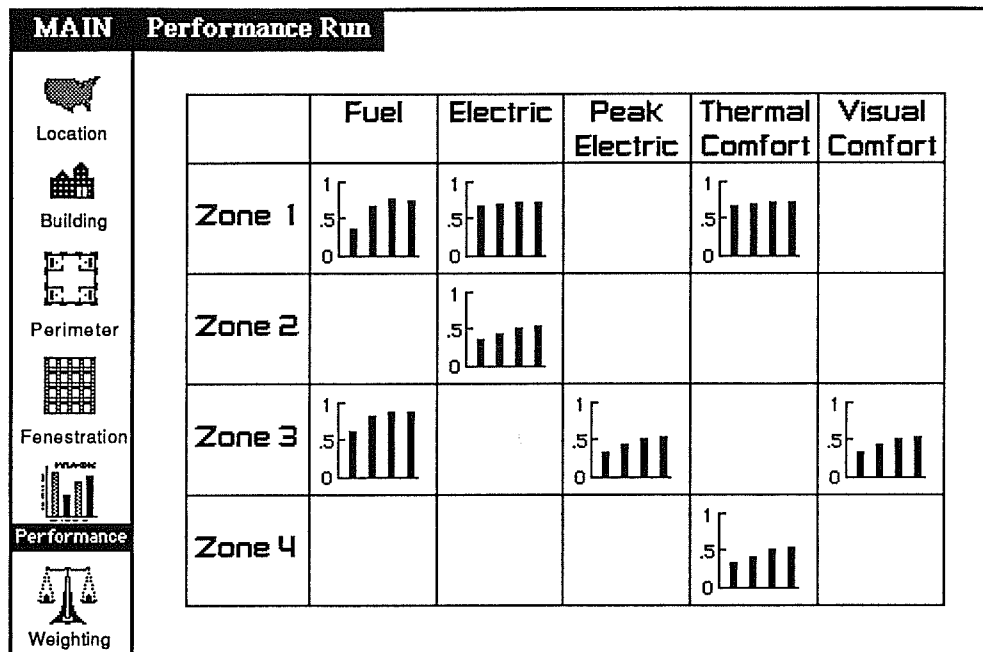


Figure 2. Performance results screen of a prototype fenestration design tool. The screen represents a consolidated output that graphically shows energy and comfort performance indices for each zone of a commercial building module for four input fenestration systems.

ENERGY INFORMATION KIOSK

The use of multimedia concepts is particularly relevant for issues related to technology transfer. LBL has developed a prototype electronic interactive Energy Information Kiosk (Sullivan, Wilde, and Selkowitz 1990) that has been used in Southern California Edison's (SCE) customer information center. The kiosk is a dual screen system consisting of a personal computer with touch screen that provides information linked to video images which are stored on an optical disk and displayed on a second screen. The kiosk uses text, graphics, animation, sound, and video to communicate effectively to users.

The kiosk serves several purposes: To demonstrate the utility's commitment to provide relevant and useful energy services to its customers, to highlight specific incentive programs, to provide contacts to people and resource materials at the utility, and to provide technical guidance to building design professionals to assist them in improving the energy efficiency of buildings. The audience for the information kiosk includes utility staff, building owners and developers, building industry professionals, including architects, engineers, and lighting designers, facilities managers, contractors and builders, building operations staff, and product manufacturers and distributors.

The kiosk has four primary parts: (1) an INTRODUCTION that is used to explain the purpose of the kiosk and how it is operated; (2) a CONCEPT path gives explanatory information about basic concepts used by the utility industry; (3) an INCENTIVE path that discusses SCE's incentive programs to assist energy efficient design; and (4) an ISSUE path that presents detailed information about many topics relevant to building design and energy efficiency.

The ISSUE path contains the bulk of the energy information that we wanted to make available to users. We developed information for five topics: Daylighting, Electric Heat Pumps, and Outdoor

Lighting in the commercial building area and Windows, Electric Heat Pumps and Heat Pump Water Heaters in the residential area. Within each topic are four data bases: WHAT (Information data base), WHY (Impact data base), HOW (Design data base), and WHO (Contact data base).

Figure 3 shows one screen from the Residential Windows portion of the kiosk. Navigation and control are supplied by the buttons that are displayed along the right side of each figure. Simply touching a particular button automatically links the user to another part of the program. Figure 3 also contains the menus for the WHAT data base: Basic Concepts, Systems and Components, Operation, and Performance Criteria. These are the graphic images in the center of the screen which function as links to the specific data base requested.

Electronic information systems such as this have tremendous potential to provide utility staff and customers with desired information in an efficient and effective format.

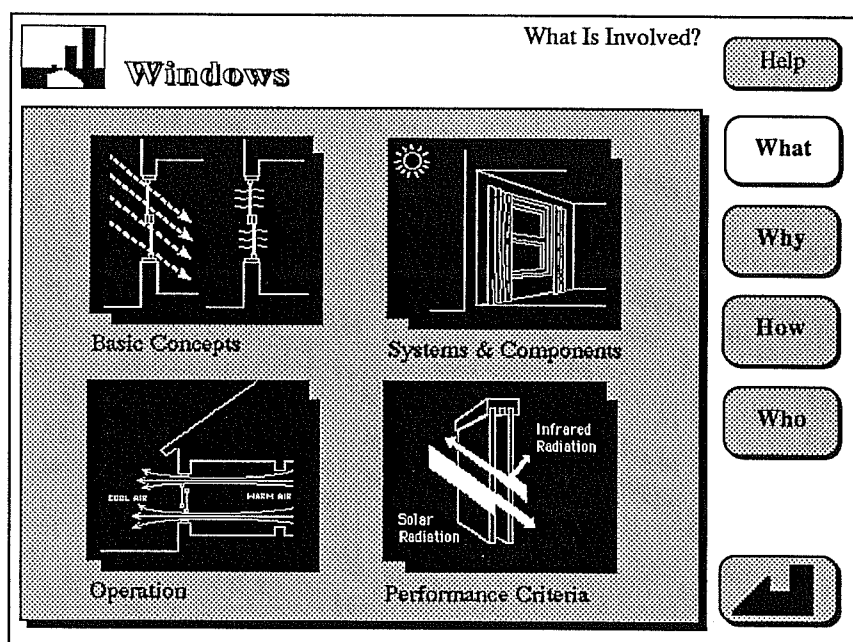


Figure 3. Sample screen from the Residential Windows portion of the Energy Information Kiosk. Primary menu items are located along the right side of the screen; while secondary menu items are displayed in the center of the screen.

CONCLUSIONS

We have discussed the use of interactive multimedia as a way of assisting building energy and comfort performance analyses, and for providing various information and education functions. Multimedia involves the integration of computer graphics, sound, still and motion video, animation, etc. with the quantitative tasks usually associated with performance evaluation. Our exploration of multimedia applications is being done through the development of operating prototypes of modules of an advanced building envelope design tool and interactive information systems. This has enabled us to better understand the various aspects of multimedia use within the context of a real-world design scenario in an architects office and as an educational and information system for utilities. We believe that multimedia tools and information systems,

although still in the early stages of development, will play a major role in future advanced design tools and in utility design assistance programs.

ACKNOWLEDGMENTS

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